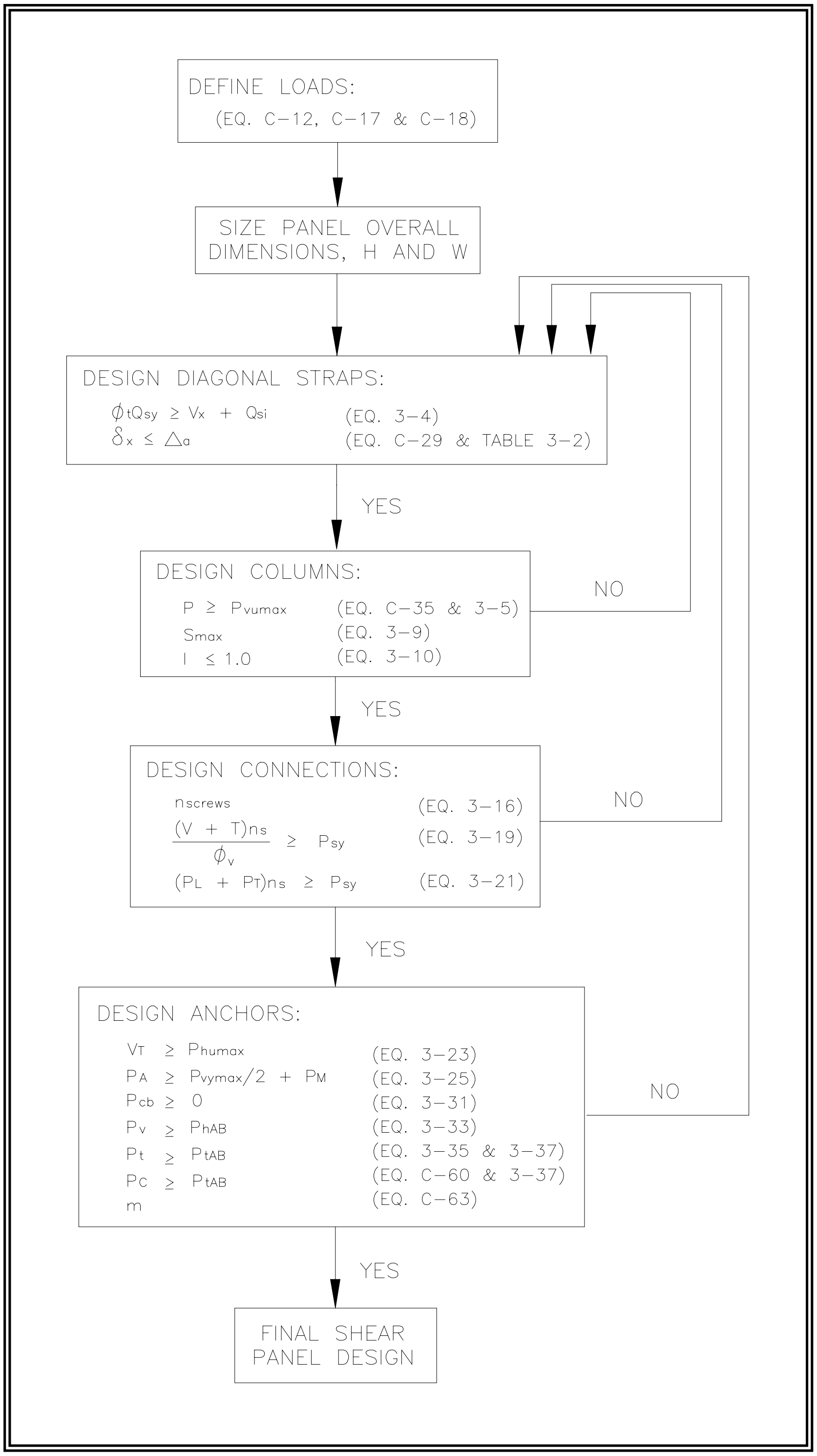
How to Use the CFS Design Spreadsheet Program [updated 10/21/98]

Introduction. The Army Corps of Engineers has mandated that cold-formed steel shear panels shall be designed following the guidance in Technical Instruction (TI) 809-07, “Design of Cold-Formed Load-Bearing Steel Systems.” Figure 3-1 from TI 809-07 (right) is a flow chart for the cold-formed steel shear panel seismic design process.



The “CFS Design Spreadsheet,” which is linked to the document you are now reading, is a Microsoft Excel worksheet that may be used to help the engineer design shear panels following the TI 809-07 guidance. To view the spreadsheet, click on the link: a read-only version of the file will open on screen. To save a copy of the file, use the Save As File function in your web browser: when the Save As File dialog box appears, specify a path to the directory of your choice on your local hard drive, then name the file “CFS Design.xls” (without the quote marks).

Spreadsheet Description. An earlier variation of the CFS Design Spreadsheet was used in the example problem presented in Appendix D of TI 809-07. Each section of the spreadsheet shows the corresponding table number from that example problem. The controlling equation numbers given in the design flow chart are shown above each corresponding column in the spreadsheet program.

The white cells in the spreadsheet are fields that require input by the user. The gray cells contain values or formulas used by the design spreadsheet, and they are locked to prevent accidental changes. The user may view these cells, however, to better understand the design process.

Each row in the spreadsheet represents a particular panel design. The first six rows are for the configuration with columns built up from cold-formed steel studs. These studs must have lips to form a C-section. The first two rows are for columns with two studs, oriented to form a closed section (see TI 809-07, Figures D-4 and D-5 for examples). The 3rd and 4th rows are for three-stud columns with the studs oriented so that the column neutral axis is closer to the outside of the panel (TI 809-07, Figures D-6 and D-7). The 5th and 6th rows are for four-stud columns with the studs oriented to form a symmetric-cross section (TI 809-07, Figure D-8). The last three rows (7th through 9th) are all for structural tubing columns (ASTM A500). Having two or more rows for each panel configuration allows the user to easily compare two alternative panel design in an iterative design process.

Step-By-Step Design Instructions. Diagonal straps are the sole lateral load-resisting element for all shear panels. Shear panels with built up studs use self-tapping screw fasteners for the diagonal strap-to-column connections. Shear panels with structural tubing columns use welded diagonal strap-to-column connections. Shear panels are designed using this program, according to the following steps:

1. Select a row or multiple trial rows based on the column configuration and number of studs per column if built-up columns.
2. Define applied story shears per shear panel, V_x (TI 809-07, Equation C-12 and C-27).
3. Define maximum gravity load, GL_{max} and minimum gravity load, GL_{min} per shear panel (TI 809-07, Equations C-17 and C18).
4. Define the importance factor for the building, I (TI 809-07, Table C-1 or FEMA 302, Table 1.4).
5. Size the overall shear panel dimensions, height, H and width, W.
6. Design the diagonal straps including number of panel faces with straps, n_s, strap width, b_s, strap thickness, t_s, strap yield strength, $F_{sy,}$ so that Equation 3-4 is satisfied.
7. Define the allowable story drift, Δ_a according to Table 3-2, and check that δ_x calculated by the program is less than Δ_a.
8. Define the ultimate, F_u and maximum estimated ultimate stress for the diagonal straps, F_{sumax}, as defined after TI 809-07 Equation 3-5.
9. Design the columns by defining the column yield stress, F_{cy}, column ultimate stress, F_{cu}, column thickness, t_c, panel thickness, b_c, and column stud flange width, b_f.
10. For structural tubing columns, define the column area, A_c and in-plane, I_x and out-of-plane moments of inertia, I_y.
11. Define the diameter, d_h or width of utility knockouts in the out-of-plane face of the columns.
12. For columns built up with studs, define the flat width, w of the column in the out-of-plane face of the columns. The default equation in the program assumes the outside radius of the studs equal to two times the stud thickness (as is done for structural

tubes). This equation should be corrected for the built-up columns if this radius is different than twice the thickness.

13. Check that the column design axial capacity, P exceeds the column axial load at the maximum ultimate stress in the diagonal straps, P_{vumax} (TI 809-07, Equations C-35 and 3-5). If not redesign the columns beginning at Step 9 above.

14. For built-up columns, select the intermittent weld length, L to determine the maximum on center spacing of these welds, S_{max} (TI 809-07, Equation 3-9).

15. Determine the maximum estimated diagonal strap yield strength, F_{symax} as defined by the note below TI 809-07, Equation 3-12.

16. Check that the column combined axial and moment interaction value, I is less than or equal to 1.0 (TI 809-07, Equation 3-10. If not redesign the columns beginning at Step 9 above.

17. For panels with built-up columns and screwed fastener diagonal strap-to-column connections, determine the number of screws needed per connection face, n_{screws} (TI 809-07, Equation 3-16). This is done by selecting the screw diameter, d and screw head diameter, d_w.

18. Check the design rupture strength of the strap for screwed diagonal strap-to-column connections by assuring the achieved resistance factor, ϕ, is less than or equal to 1.0. This requires the calculation of the tension/shear net area, A_{nvt} and tension net area, A_{nt} along a critical rupture surface as shown in the example connections shown in TI 809-07, Figures D-4 through D-8.

19. For panels with structural tube columns and welded diagonal strap-to-column connections, the length of fillet welds loaded in the longitudinal and longitudinal/transverse (along the strap ends) directions are determined (see TI 809-07, Figure D-9 for an example). Check that the weld design strength, $(P_L + P_{LT})n_s$ exceeds the yield strength of diagonal strap, P_{sy} (TI 809-07, Equation 3-21).

20. Determine the column-to-angle weld thickness, t_w by selecting the heaviest weld allowed according to TI 809-07, Table 3-3 based on the column material thickness, t_c.

21. Select the panel anchor angle thickness, t_A by selecting the maximum thickness allowed according to TI 809-07, Table 3-4 based on the weld thickness, t_w.

22. Determine the anchor angle yield strength, F_{yA}, height, H_A, width, W_A, angle k value (see TI 809-07, Equation 3-29).

23. Check that the total design shear strength, V_T exceeds the maximum shear panel horizontal seismic force, P_{humax} (TI 809-07, Equation 3-23).

24. Select the thickness of the plate, t_p that rests over the horizontal leg of the anchor angle, distance from anchor the anchor bolts to the column face, d_c, nut width, W for trial anchor bolts of diameter, d_{AB}, so that TI 809-07, Equation 3-25 is satisfied. This

requires that the column-to-angle weld strength, P_A exceeds the total uplift force applied to one angle on one side of a column, $P_{vymax}/2 + P_M$.

25. Determine the diagonal strap eccentricity, L_s as defined below TI 809-07, Equation 3-32.

26. Check that the angle uplift capacity that remains to resist column bending, P_{cb} exceeds zero (TI 809-07, Equation 3-31). If not resize the column anchor layout beginning at Step 22 above or increase the column thickness if needed beginning at Step 9.

27. Determine the number of anchor bolts per column, n_{AB}, anchor bolt diameter, d_{AB}, and anchor bolt type (e.g., ASTM A325 or A307), and corresponding shear, F_v and tensile strengths, F_t. These strengths are determined according to AISC LRFD, Table J3.2, "Design Strength for Fasteners." Check that the anchor bolt shear design strength, P_v exceeds the applied shear load per bolt, P_{hAB} (TI 809-07, Equation 3-33). Change the value for W in Step 24 above for the selected anchor bolt diameter if it differs from the value used in Step 24.

28. Check that the anchor bolt tensile strength, P_t exceeds the applied tensile force per bolt, P_{tAB} (TI 809-07, Equations 3-35 and 3-37 respectively). If not resize the panel anchor bolts beginning at Step 27 above, or increase n_{AB} to four if currently two.

29. Determine the out-of-plane space between anchor bolts, $d_{c\text{-}c}$, anchor bolt embedment length, l_{AB} and concrete compressive strength f'_c. Check that the anchor bolt cone failure design strength, P_c exceeds P_{tAB} (TI 809-07, Equations C-60 and 3-37, respectively). If not change the values defined in this step.

30. Determine the minimum distance from the center of an anchor bolt to the edge of the concrete, m to prevent side cone failure (TI 809-07, Equation C-63).

31. A final shear panel is obtained when all of the above steps are satisfied.

Point of Contact. If you have questions about the spreadsheet, please contact:

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